FREQUENCIES OF MONTHLY AND SEASONAL RAINFALLS OF VARIOUS DEPTHS AT SAN JOSE, CALIF.

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[Weather Bureau Office, San Jose, Calif., September 6, 1923.]

The fact that a statement of monthly and annual averages of precipitation gives a very inadequate idea of the variation from month to month and from year to year is well illustrated by the rainfall record of San Jose, which is situated in the Santa Clara Valley of California near the southern end of San Francisco Bay.

Since July 1, 1906, the official rain gage, which is of the standard tipping-bucket self-recording type, has been exposed in City Hall Park with the top of the collecting funnel 3 feet above ground. The records for the 17-year period since that date form a homogeneous series. Also, there are available readings for the 32 years immediately preceding, mostly taken by cooperative observers in various locations about the city; and for a few months made at the former location of the regular Weather Bureau station previous to its destruction during the great earthquake and fire of April 18, 1906.

Table 1 gives the individual monthly, seasonal, and yearly amounts of rainfall for the 17-year period, September, 1906, to August, 1923, inclusive, years beginning with September 1; and the monthly, seasonal, and annual averages for the same 17-year period, as well as for the entire 49-year period beginning September 1, 1874.

TABLE 1.—*Monthly, seasonal, and annual precipitation at San Jose, Calif., 1906–1923.*

Year.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	Fall.	Winter.	Spring.	Summer.	Total.
1906-7	0.13	0.01	0.98	6.39	4.61	1.88	7.75	0.46	0.08	0.42	T.	0	1.12	12.88	8.29	0.42	22.71
1907-8	0.06	0.98	0.13	3.65	2.63	2.46	1.14	0.23	0.67	0.01	0	0	1.17	8.74	2.04	0.01	11.96
1908-9	0.09	0.19	1.11	1.54	7.69	4.87	2.77	0	0	0.05	0	0	1.39	14.10	2.77	0.05	18.31
1909-10	0.75	0.72	1.27	5.41	2.31	0.83	2.84	0.41	T.	0.02	T.	0	2.74	8.55	3.25	0.02	14.56
1910-11	0.09	0.20	0.28	0.68	12.38	2.03	6.26	0.45	0.21	0.07	T.	0	0.57	15.09	6.92	0.07	22.65
1911-12	0	0.80	0.18	2.03	1.36	0.30	2.80	1.95	0.70	0.46	T.	0	0.98	3.69	5.45	0.46	10.58
1912-13	0.71	0.21	0.29	0.43	2.29	0.09	1.17	0.38	0.77	0.01	0.09	0.08	1.21	2.81	2.32	0.18	6.52
1913-14	T.	0.02	4.10	3.00	6.23	3.94	0.90	0.65	0.19	0.25	0	0	4.12	13.17	1.74	0.25	19.28
1914-15	0	0.50	1.36	3.73	4.85	7.02	1.49	1.07	2.69	0	0	0.04	1.86	15.60	5.25	0.04	22.75
1915-16	0	0	0.19	4.37	8.71	1.83	1.10	0.06	0.01	T.	T.	0.01	0.19	14.91	1.17	0.01	16.28
1916-17	0.78	0.84	0.41	3.48	0.98	4.88	0.77	0.26	0.22	0	T.	0	2.03	9.34	1.25	T.	12.62
1917-18	0.01	0	0.54	0.55	0.70	2.63	4.48	0.45	T.	0	0	0	0.55	3.88	4.93	0	9.36
1918-19	6.33	0.15	2.24	1.28	1.06	4.87	2.87	0.06	0.01	T.	T.	0.01	8.72	7.21	2.94	0.01	18.88
1919-20	0.25	0.28	0.09	2.48	0.10	1.04	3.43	0.92	T.	0.21	0	0	0.62	3.62	4.35	0.21	8.80
1920-21	0.02	1.71	1.84	3.58	4.75	1.09	0.80	0.40	0.82	T	0	0	3.57	9.42	2.02	T.	15.01
1921-22	0.21	0.21	1.65	4.66	2.46	3.01	1.74	0.32	0.50	0.01	T.	T.	2.07	10.13	2.56	0.01	14.77
1922-23	0	1.55	2.72	4.68	1.93	1.02	0.31	1.52	0.02	0.10	0	.01	4.27	7.63	1.85	0.11	13.86
17-year averages	0.55	0.49	1.14	3.06	3.83	2.58	2.51	0.56	0.41	0.09	T.	0.01	2.18	9.47	3.48	0.10	15.23
49-year averages	0.35	0.72	1.50	2.64	3.05	2.45	2.66	1.08	0.55	0.11	T.	0.02	2.57	8.14	4.29	0.13	15.13

On the line diagram, Figure 1, have been plotted both the 17-year and the 49-year monthly averages. The dry summer and the comparatively wet winter typical of Pacific coast climates are clearly shown. If the February amount were corrected for length of that month,

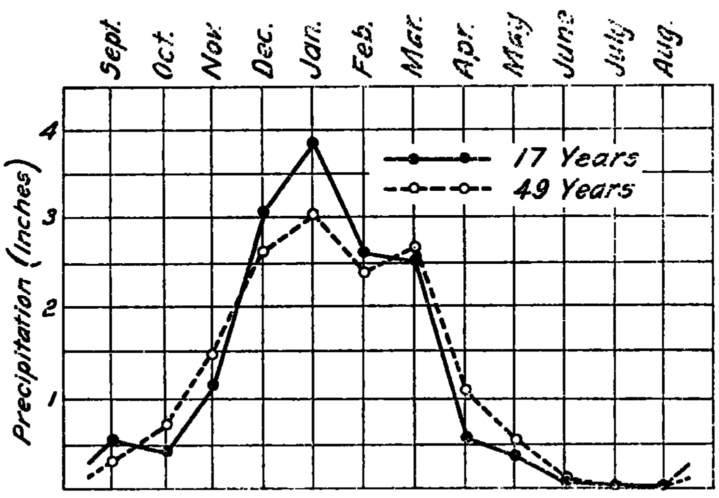

FIG. 1.—Average monthly precipitation at San Jose, Calif., as shown by a 17 and 49 year record.

progress of the lines from January through February to March would be smoothed considerably. The longer record gives the smaller winter averages; but larger in spring and fall; and the yearly totals are practically identical, showing that San Jose's climate is not changing in this respect, at least.

Figure 2, based on a portion of Table No. 1, is a bar diagram that shows the progressive totals by tri-monthly seasons beginning with September for each year of the 17-year period considered. The amounts of precipitation are shown by lengths of vertical bars as measured by the scale of inches at the left of the diagram. The lengths of the lowest sections of the bars, unshaded, and the height of the lowest horizontal line above the base indicate, respectively, the individual seasonal and the average totals for the trimonthly period (season), September to November, inclusive.

Similarly, the lengths of the next higher sections of the several bars (shaded longitudinally) give the individual seasonal totals for December to February, inclusive, and the height of the second horizontal line above the first shows the average total for these three months. Of course, the heights of the tops of the several longitudinally shaded sections, and of the second horizontal bar, above the base indicate, respectively, the individual seasonal and the average totals from September to February, inclusive. Likewise, the spring and summer totals, the annual totals, etc., are shown by the third (clear) and the fourth (crosshatched) sections of the bars and by the third and fourth horizontal lines above the base.

No clear evidence of periodicity appears in Figure 2; but in two cases a pair of dry years was preceded by a trio of wet ones. A cursory inspection of Table 1 and of Figure 2 shows that average values are not more likely to occur than are amounts differing considerably therefrom. This is graphically shown by the frequency diagrams, Figures 3 and 4, in which the numbers of times the total monthly, seasonal, and annual precipitation

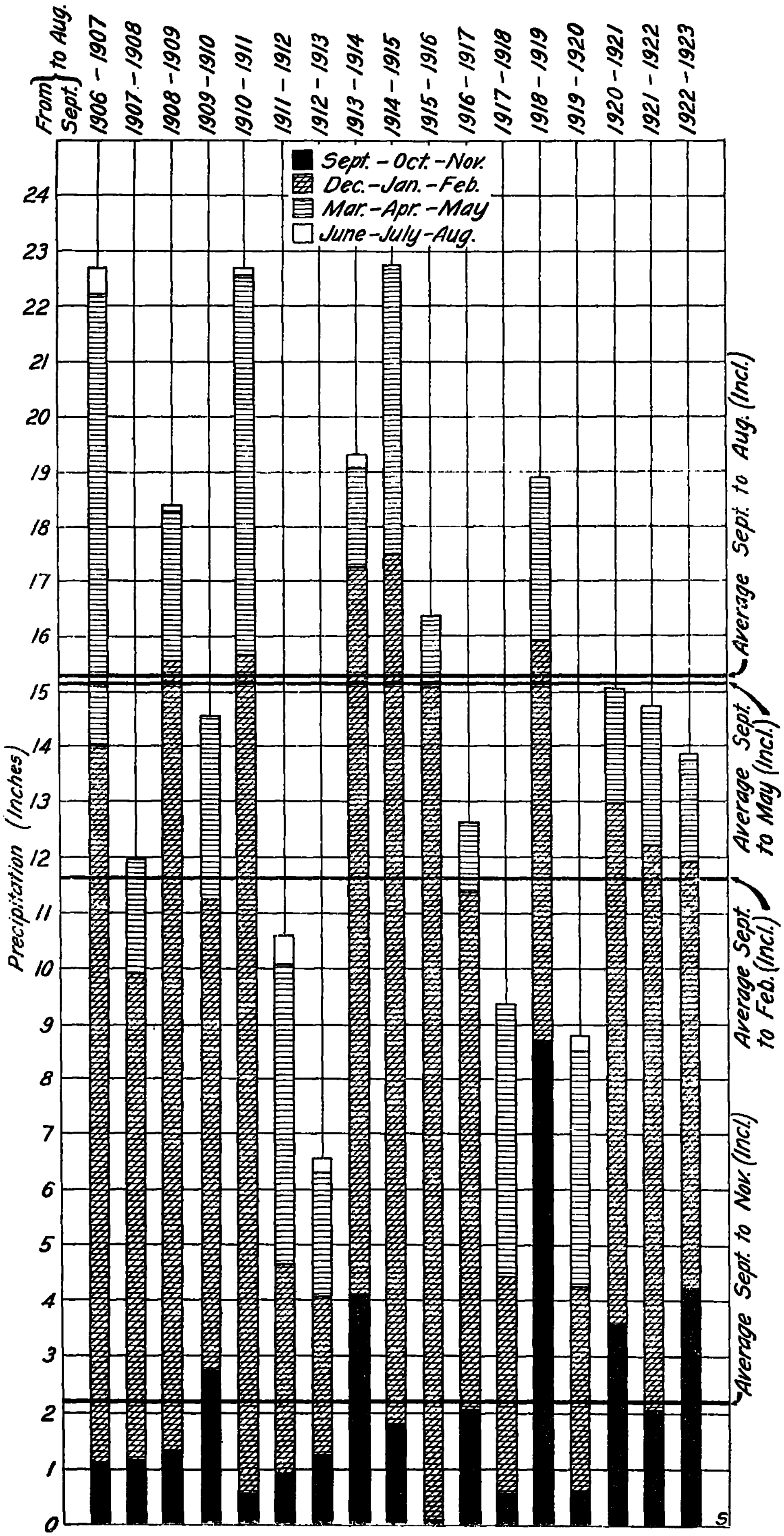

FIG. 2.—Seasonal precipitation, San Jose, Calif., September, 1906, to August 1923, inclusive.

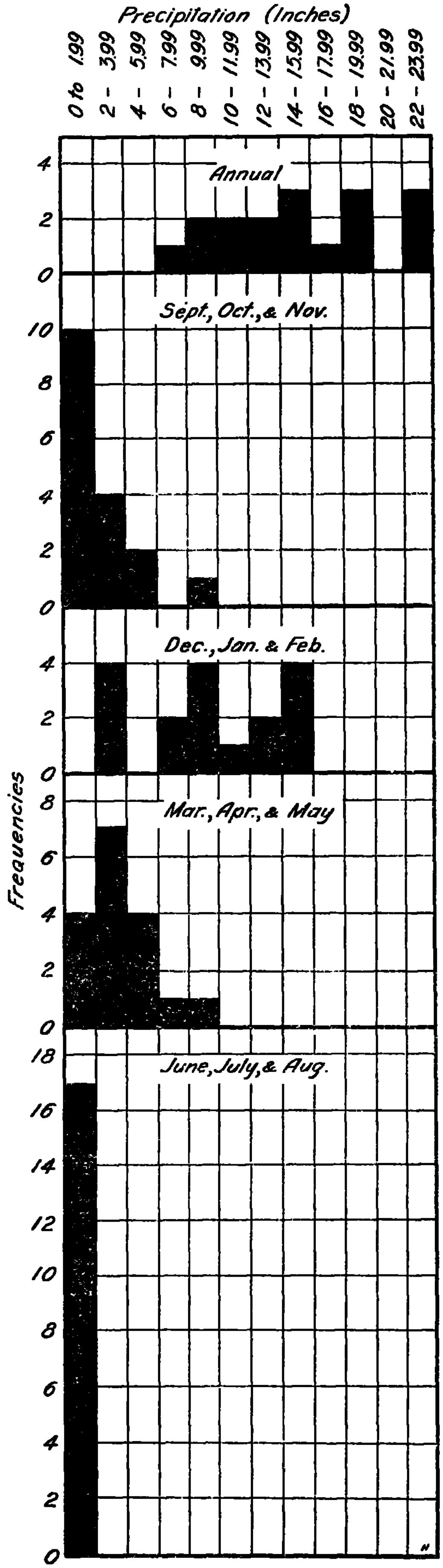

FIG. 3.—Trimonthly and annual precipitation frequencies at San Jose, Calif.

lay between certain limits are given by the lengths of bars as measured by scales at the left of the diagrams.

Figure 3 has a section for the year and one for each quarter year (of three calendar months), beginning the year September 1; and gives the frequencies for our 17-year period in 2-inch classes, beginning with 0 to 1.99 inches as the lowest class. This figure shows that the most frequent amount (that is, the "mode") for the fall months, September, October, and November, inclusive, is less than 2 inches; that the summer rainfall invariably falls within this lowest class; that the most frequent in spring is the second class, 2 to 3.99 inches; that winter amounts vary widely, the second class being as frequent as the eighth (14 to 15.99 inches); that annual amounts vary widely also.

Figure 4 has a section devoted to each month of the year. As the 17-year record shows no pronounced mode for certain months the preceding 32-year record (using data tabulated in section 14, "Climatological data for the U. S. by sections") has been added by proper lengthening of the several bars; 17-year record crosshatched, 32-year, clear. Here we have used half-inch intervals in classifying the precipitation.

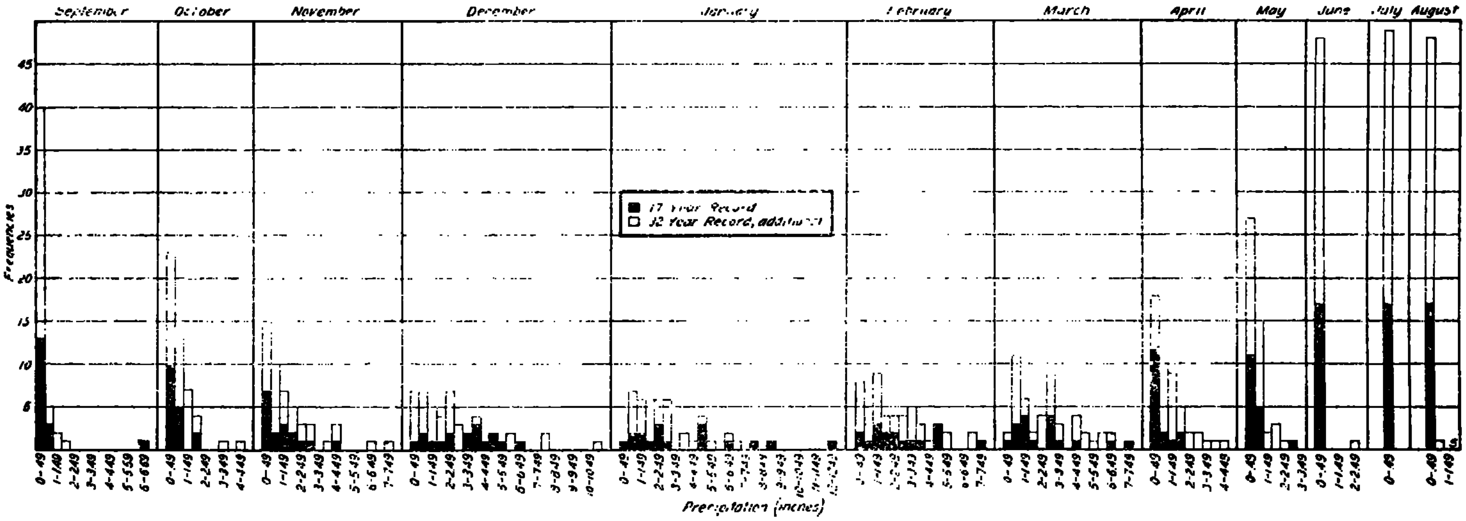

FIG. 4.—Monthly precipitation frequencies, San Jose, Calif., from a 17 and 32 year record.

TABLE 2.—*Precipitation frequencies at Santa Clara, Calif., for 17 years and 49 years, respectively.*

	0.00 to 0.49.	0.50 to 0.99.	1 to 1.49.	1.50 to 1.99.	2 to 2.49.	2.50 to 2.99.	3 to 3.49.	3.50 to 3.99.	4 to 4.49.	4.50 to 4.99.	5 to 5.49.	5.50 to 5.99.	6 to 6.19.	6.50 to 6.99.	7 to 7.49.	7.50 to 7.99.	8 to 8.49.	8.50 to 8.99.	9 or more.	Total.
September	13	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	17
	27	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
October	10	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	13	8	7	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	32
November	7	2	3	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	17
	8	8	4	3	2	2	0	1	2	0	0	0	1	0	1	0	0	0	0	32
December	1	2	1	1	2	0	2	3	1	2	1	0	1	0	0	0	0	0	0	17
	6	5	4	3	5	3	0	1	0	0	0	2	0	0	0	2	0	0	1	32
January	1	2	2	1	3	1	0	0	0	3	0	0	1	0	0	1	1	1	0	17
	0	5	4	5	3	5	2	2	1	1	1	1	1	1	0	0	0	0	0	32
February	2	1	3	2	2	1	1	1	0	3	0	0	0	0	1	0	0	0	0	17
	6	2	6	2	2	3	4	2	1	0	2	0	0	2	0	0	0	0	0	32
March	1	3	4	1	0	4	1	0	1	0	0	0	1	0	0	1	0	0	0	17
	1	8	2	1	4	5	2	0	3	2	1	2	1	0	0	0	0	0	0	32
April	12	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	6	8	8	3	2	2	1	1	1	0	0	0	0	0	0	0	0	0	0	32
May	11	5	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	16	10	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
June	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	31	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
July	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
August	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17
	31	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32
Year	109	25	14	11	8	8	4	4	3	8	1	0	4	0	1	2	1	1	0	204
	177	57	39	23	20	20	10	7	9	3	4	5	3	3	1	2	0	0	1	384

TABLE 3.—*Precipitation frequencies: Seasonal and annual, 17 years.*

Periods.	0 to 1.99.	2 to 3.99.	4 to 5.99.	6 to 7.99.	8 to 9.99.	10 to 11.99.	12 to 13.99.	14 to 15.99.	16 to 17.99.	18 to 19.99.	20 to 21.99.	22 to 23.99.	24 to 25.99.	26 to 27.99.	Total.
September-August, inclusive	0	0	0	1	2	2	2	3	1	3	0	3	0	0	17
September, October, November	10	4	2	0	1	0	0	0							17
December, January, February	0	4	0	2	4	1	2	4							17
March, April, May	4	7	4	1	1	0	0	0							17
June, July, August	17	0	0	0	0	0	0	0							17
Trimonthly	31	15	6	3	6	1	2	4							68

Amounts for each June, July, and August of the entire 49 years fall within the lowest class (less than one-half inch), with the exception of one June and one August. The same class is plainly the mode for September, October, November, April, and May; and is very frequent in the early 32-year record for December and February, although other classes are equally or somewhat more frequent. Several classes are about equally frequent in January, all above one-half inch. The four months, December to March, inclusive, have no one strongly out standing class, but show wide variations. March has two modes, the second and sixth classes, probably because this is a transition month, between the wet and the dry seasons.

Plainly, the summer rainfall is practically negligible, as far as benefit to soil and vegetation is concerned; appreciable amounts are simply damaging to fruit and other matured crops. Fall amounts are usually light, but have varied from practically nothing to over 8½ inches. Early fall rains are damaging to drying fruit and other matured crops; but late fall precipitation is beneficial.

The greatest amounts usually fall in winter, though sometimes spring is ahead, and in one very exceptional case fall produced more than any other quarter of the year. Spring amounts are variable, but are sufficient to benefit growing vegetation.

Dry seasons and months are more frequent than wet ones; excesses are greater than deficiencies; the mode is less than the mean. For instance, the November average is over 1 inch, but the most probable amount for that month is less than one-half inch. The annual totals have varied from about 6.5 to 22.5 inches (during the 17-year period); in some seasons the amount is so slight that even fall-sown grains benefit by irrigation. Still more is irrigation desirable for spring-sown crops; it is essential to crops growing through the summer, except in case of trees with a good supply of underground water. It is fortunate that much of the Santa Clara Valley is underlain at slight depth by gravel beds, which form excellent storage reservoirs and are tapped by numerous wells, from which a large supply of water is pumped.

TYPHOON AT GUAM, M. I., MARCH 19-27, 1923.

By J. H. WEST and J. D. SWARTWOUT.

[U. S. M. C. Scouting Squadron One, Sumay, Guam, M. I., July 27, 1923.]

Although the barometric pressure showed a slight drop of a few hundredths of an inch on March 19, 1923, there were no further or conclusive signs of a nearing area of low pressure. However, on the morning of the 20th, just at sunrise, we noted about three-tenths of cirrus, all in very fine lines and with a pronounced point of convergence in the SE. The signs were unmistakable. The pressure on the 20th reached a maximum of 29.89 inches at 10 a. m., while on the 19th the maximum was 29.91 inches at 9 a. m. The minimum pressure on the 19th was 29.83 inches at 4 p. m. and on the 20th 29.80 at 3 p. m. The approach of an area of low pressure was recorded in the Aerological Journal on the 20th.

The pressure continued to drop slowly for three days without any effect on the diurnal variation.

We had observed similar occurrences before lasting from two to five days. After the first day in which the pressure dropped in these previous occurrences, the wind had shifted slightly each day, showing that the center of the depression was passing around us. The winds from March 19 to 22, inclusive, did not shift at all, but blew steadily from a general ENE. direction, the highest velocity during that time being recorded as 22 miles per hour, at 3 p. m. on March 21.

On the 23d the winds shifted slightly to the N., coming from NE. and NNE. and increasing to a velocity of 27 m. p. h. at 9 p. m. Up to March 23, cirrus and cumulus had been the predominating clouds, but on the 23d from three to five tenths of cirro-stratus, strato-cumulus, alto-stratus, and stratus were recorded at different times throughout the day.

The morning of the 24th this office issued a typhoon warning, which was sent through the commanding officer of Scouting Squadron One, this office not being allowed to broadcast any messages directly, as all communications must go through official channels.

From midnight of March 24 eye readings of the mercurial barometer were taken at 30-minute intervals or oftener, up to 3 p. m. on the 25th, when we started to take readings of the barometer and wind direction and force at 12 and finally 6 minute intervals. At Lieutenant Swartwout's suggestion and with his aid we started to make a chart on millimeter paper, of the barometric curve. This chart required the attention of one man from 8 a. m. March 25 to about 4 a. m. March 27, when the direction of the wind showed that the typhoon was passing around us.

During the time between 8 a. m., March 25, and 8:40 a. m., 27th, the anemometer buzzer was connected with extra batteries and fixed so that it buzzed continuously. By noting the sudden increase in the number of buzzes, and counting them for five-second periods, gusts were recorded as high as 156 m. p. h. This highest velocity was reached at 3:24 and 3:30 a. m., March 26. At 8:40 a. m. the 26th the anemometer cups were blown away and no further wind velocities could be obtained.

The wind showed a slight shift about midnight the 25th, registering then about 70°. Throughout the 26th the wind showed a tendency to move farther toward the south and by midnight this date it was coming from 155°.

The rainfall during this period was quite heavy. On the 24th there was about 0.44 inch, on the 25th 2.01 inches, 26th, a continuous rain throughout the day registered 4.84 inches and on the 27th in the a. m. 0.85 inch. This is not absolutely the correct amount of rain for that period, as proper care could not be given to the instruments after one of the men in the aerological office was severely injured, leaving only two men.

The remarkable feature of the typhoon was the large, but slow, pressure drop, and the conspicuous diurnal effect which shows clearly even at the point of lowest pressure. The slow, steady, drop was indeed very puzzling to us during the first few days of the low pressure. Our first theory, that the typhoon was moving toward us from the SE. and that it was about 200 miles away when we first started to feel its effect, had to be discarded. It took practically seven days for the barometer to reach its lowest point after it started dropping. Even if the typhoon had been moving at the slow rate of 5 miles an hour and had been 200 miles away when we first started to feel its effect, it would have been about 650 miles past us by the time the pressure here was the lowest. Suppose the typhoon had been traveling at the